LUNAR FIELD WORK AND EVA PLANNING BASED ON SCIENCE RATIONALE

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INTRODUCTION

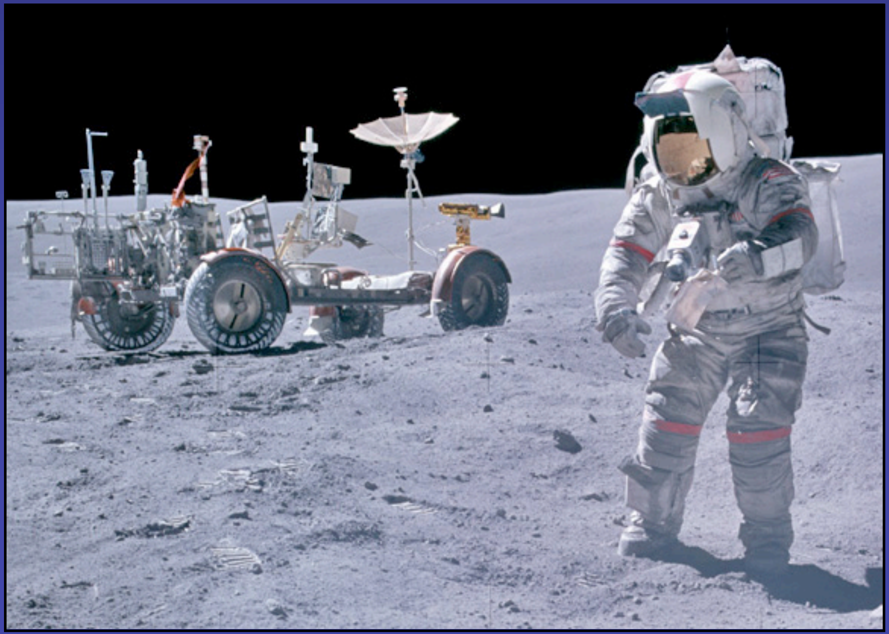
- Lunar Surface Systems Project (LSSP) of Constellation Program Office (Cx)
  - Designs for lunar surface systems supporting future human missions
  - Establish diverse engineering teams and working groups
  - Develop surface scenarios to set operational context
- Optimizing Science & Exploration Working Group (OSEWG) at HQ
  - Creating science based surface scenarios
  - Reference for engineering trade studies

INTRODUCTION

- OSEWG Surface Scenarios Working Group examining 3 options:
  1) ~ 7 days, 10 km radial distance
  2) ~ 45 days, 100 km radial distance
  3) ~180 days, 1000 km radial distance
- This talk reviews the results of a two day planning exercise for option 1
  – Two teams of four scientists with lunar and field backgrounds
  – Task: Identify site-specific surface science objectives, then design a site exploration strategy
  – Results presented to Cx members
  – Recommendations

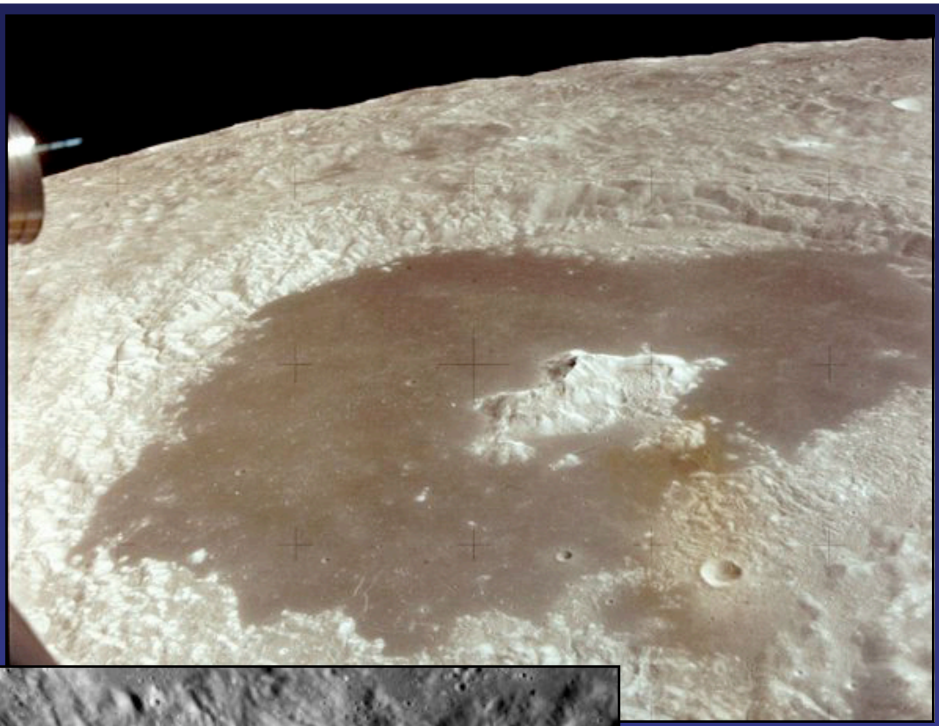
TECHNICAL CONSTRAINTS

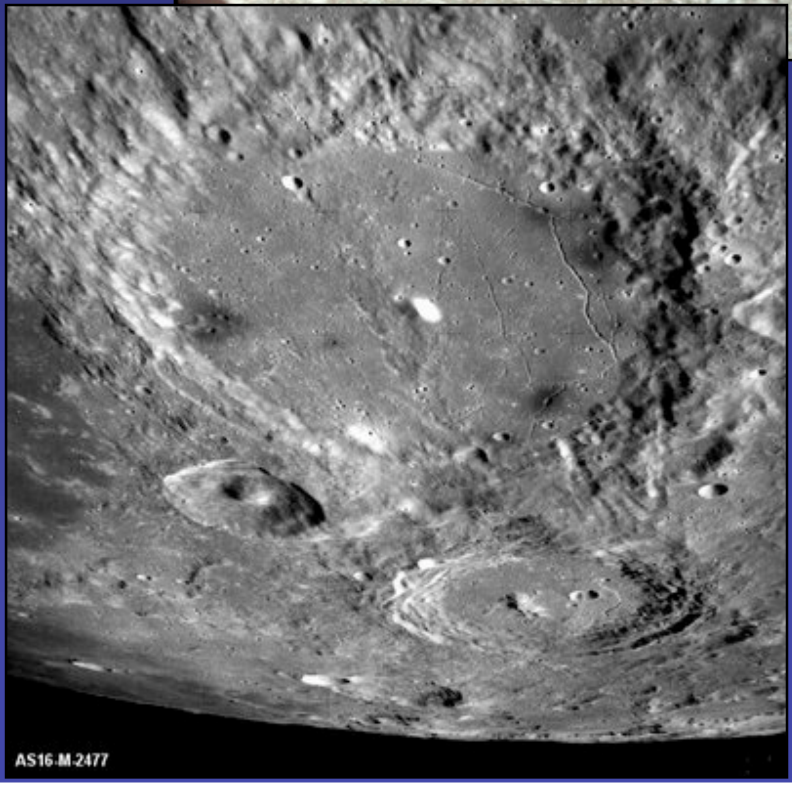
- 4 astronauts
- 2 unpressurized rovers
- 8, 2-person EVAs (8 hours)
- Maximum "walk back" distance of 10 km
- Can exceed maximum distance by using all 4 astronauts and both rovers
- Study areas:
  - Tsiolkovskiy Crater
  - Alphonsus Crater



STUDY AREAS

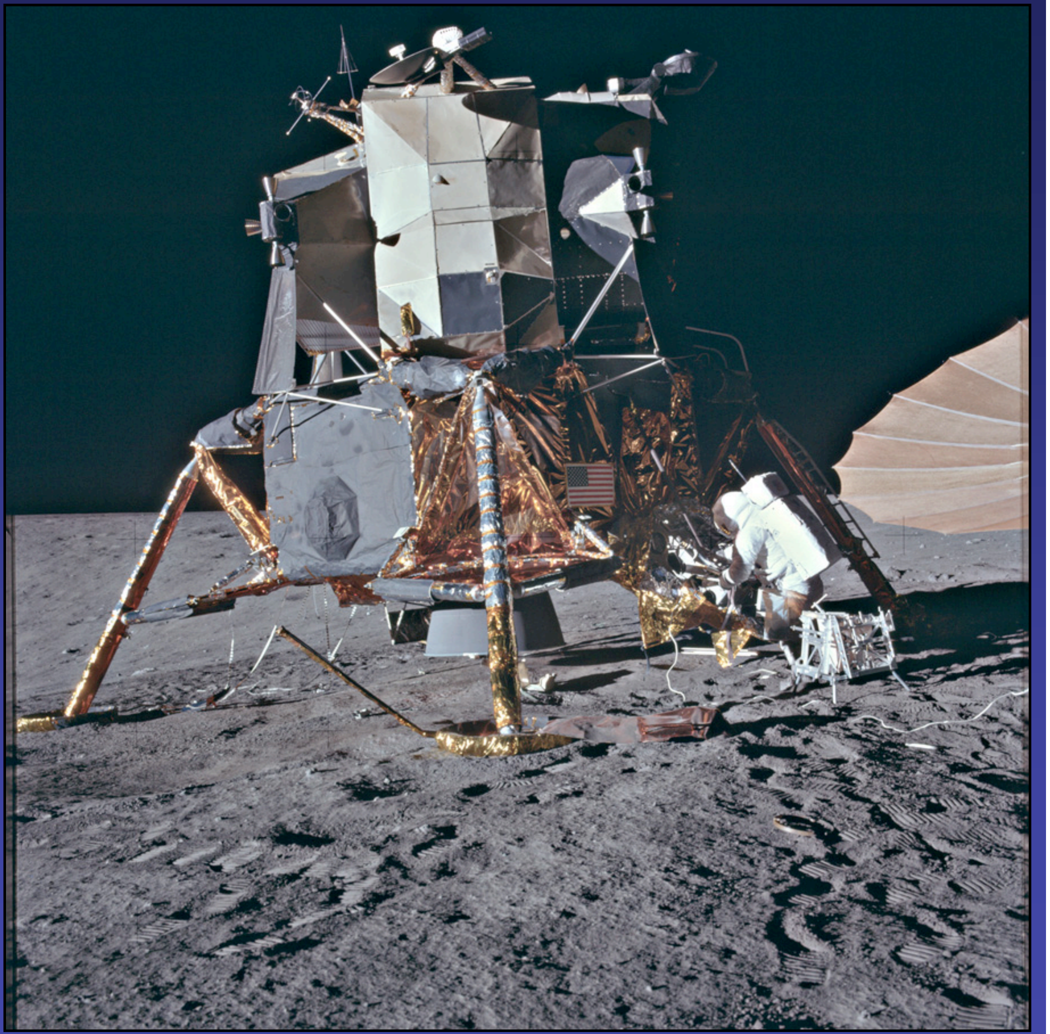
- Tsiolkovskiy
  - 20 S, 129 E (far side)
  - ~190 km complex crater
  - Imbrian age
  - Central peak
  - Mare fill
- Alphonsus
  - 13 S, 357 E (near side)
  - ~ 118 km complex crater
  - Pre-Imbrian age
  - Central peak
  - Central ridge
  - Pyroclastic deposits
  - Floor fractures
  - Ranger IX impact site





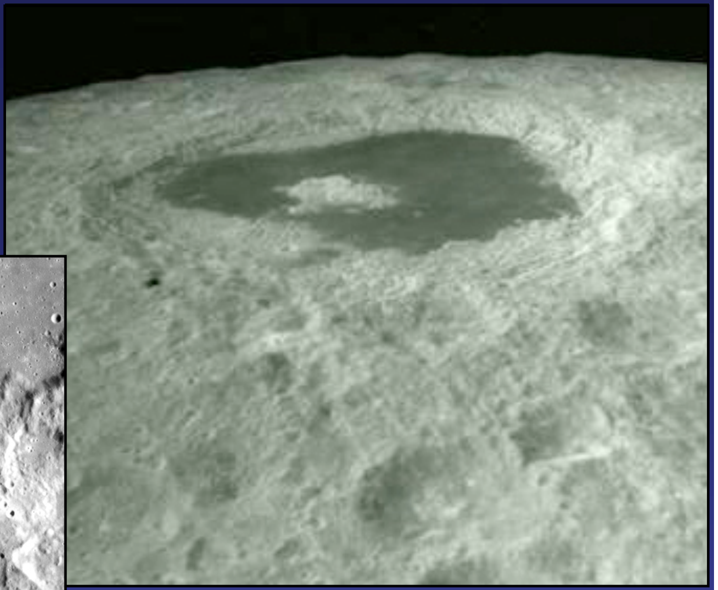
NRC LUNAR SCIENCE CONCEPTS

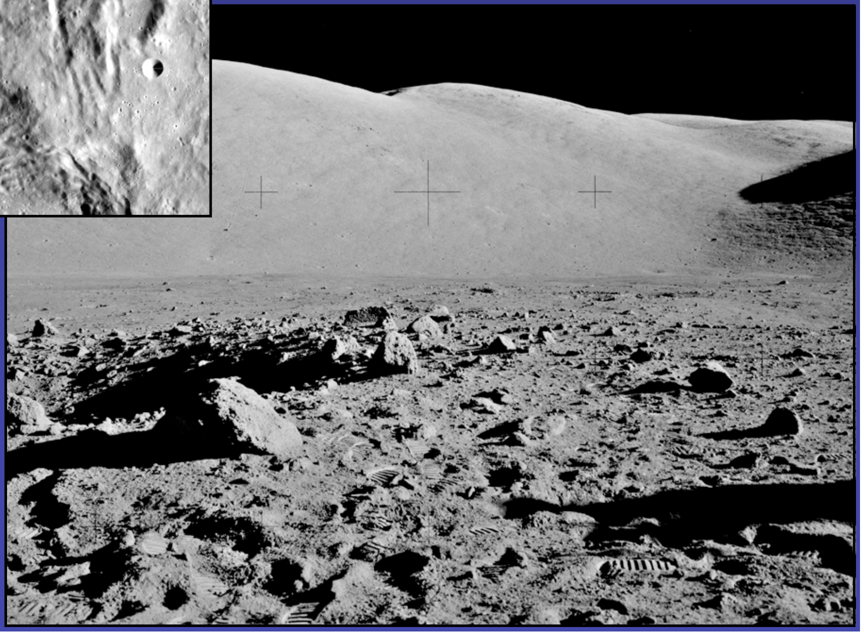
1. Bombardment history
2. Structure and composition of the lunar interior
3. Structure, composition, and variability of the crust
4. Volatiles at the poles
5. Volcanic history
6. Impact processes
7. Regolith processes and weathering
8. Lunar atmosphere and dust environment



OVERARCHING SCIENTIFIC RATIONALE

- Targets:
  1. Surface/shallow subsurface crust materials (crater walls, melt sheets)
  2. Subsurface crust materials (central peaks)
  3. Deep crust/mantle materials (volcanic deposits)
  4. Regolith
  5. Impact craters





- Both teams chose to land inside the crater cavity

OVERARCHING SCIENTIFIC RATIONALE

- Targets:
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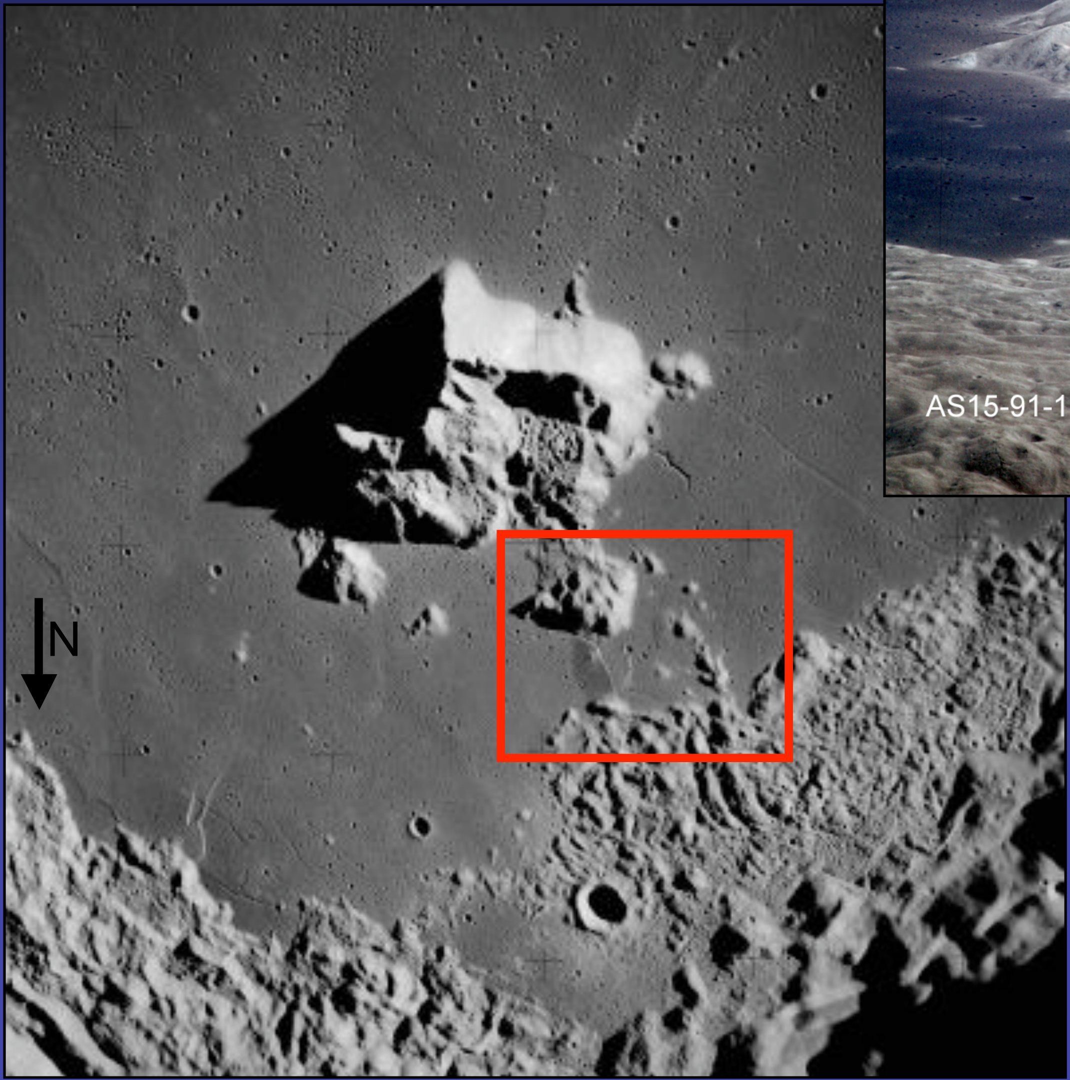
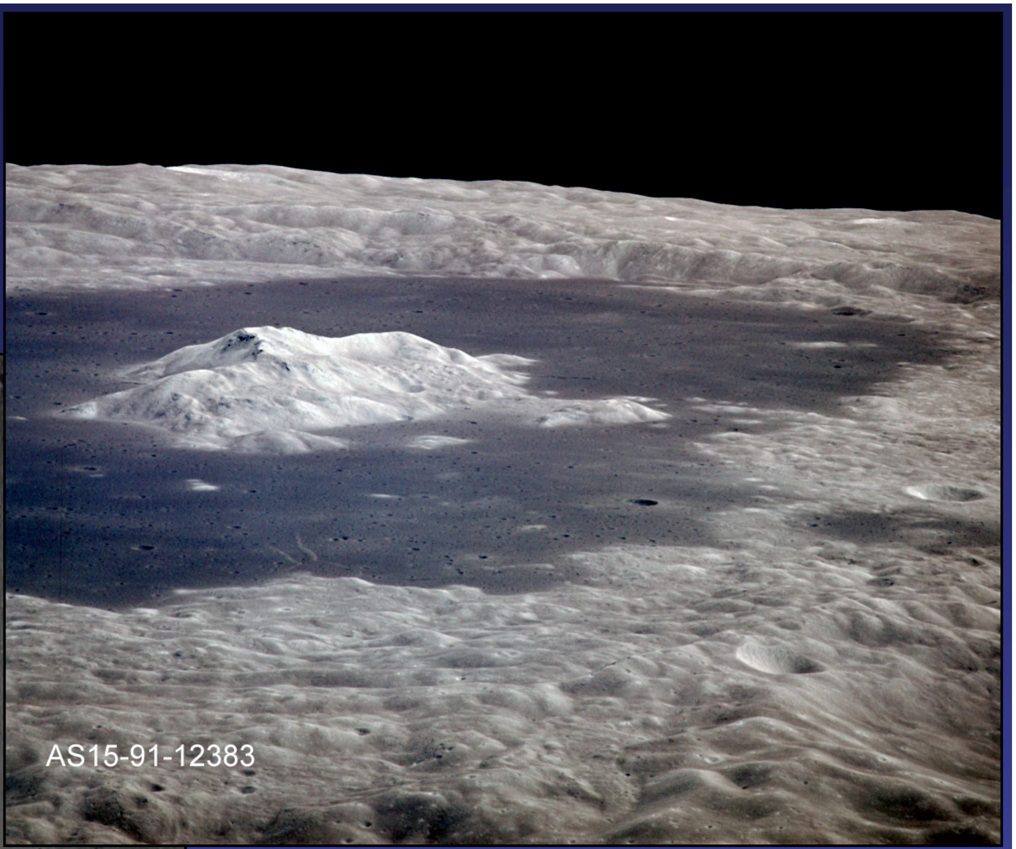
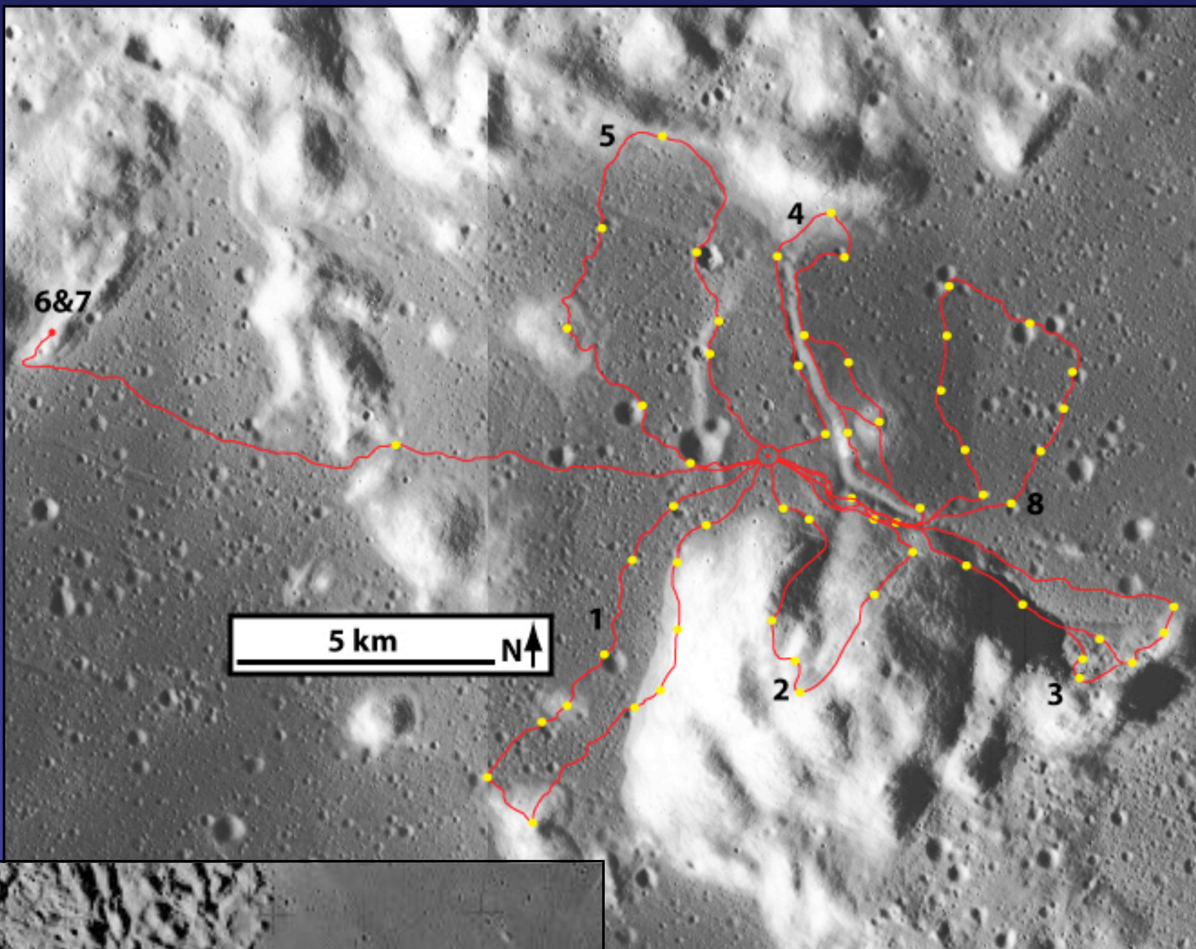
  2. Subsurface crust materials (central peaks)
  3. Deep crust/mantle materials (volcanic deposits)
  4. Regolith
  5. Impact craters
- Objectives:
  1. Reconstruct crustal lithologies, average composition of crust, lateral variability
  2. Assess lateral and vertical heterogeneity of crust, origin of secondary crust (Mg-suite), bulk composition of crust
  3. Assess heterogeneity of mantle, depth of melting, degree of differentiation, lava flow stratigraphy, volatile content
  4. Assess regolith formation processes, lateral vs. vertical mixing, reconstuct farside crustal lithologies, exotic components
  5. Assess extent of lateral mixing of ejecta, relate surface ages to crater retention, constrain current impact flux (Ranger IX)

TSIOLKOVSKIY



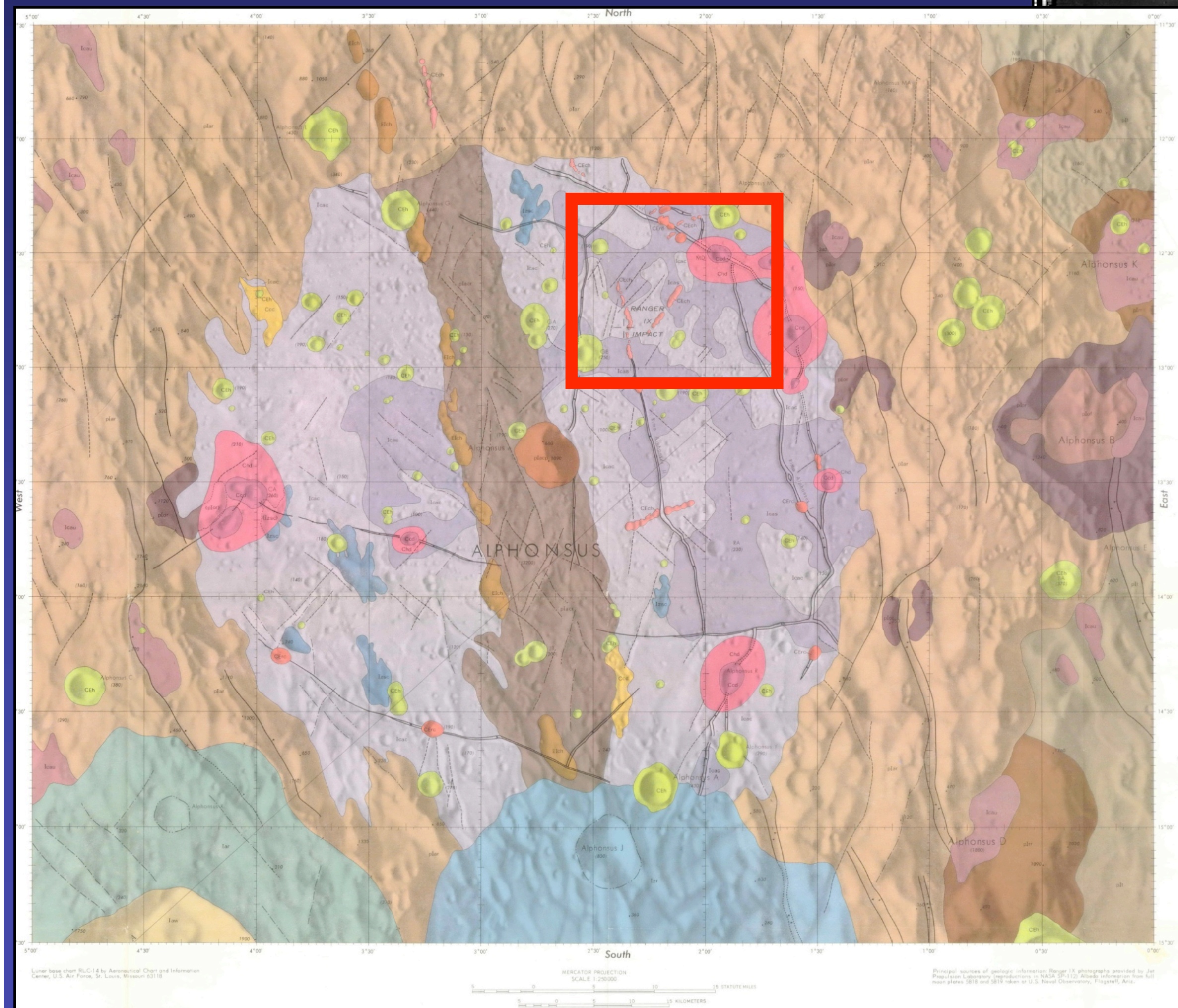


TSIOLKOVSKIY

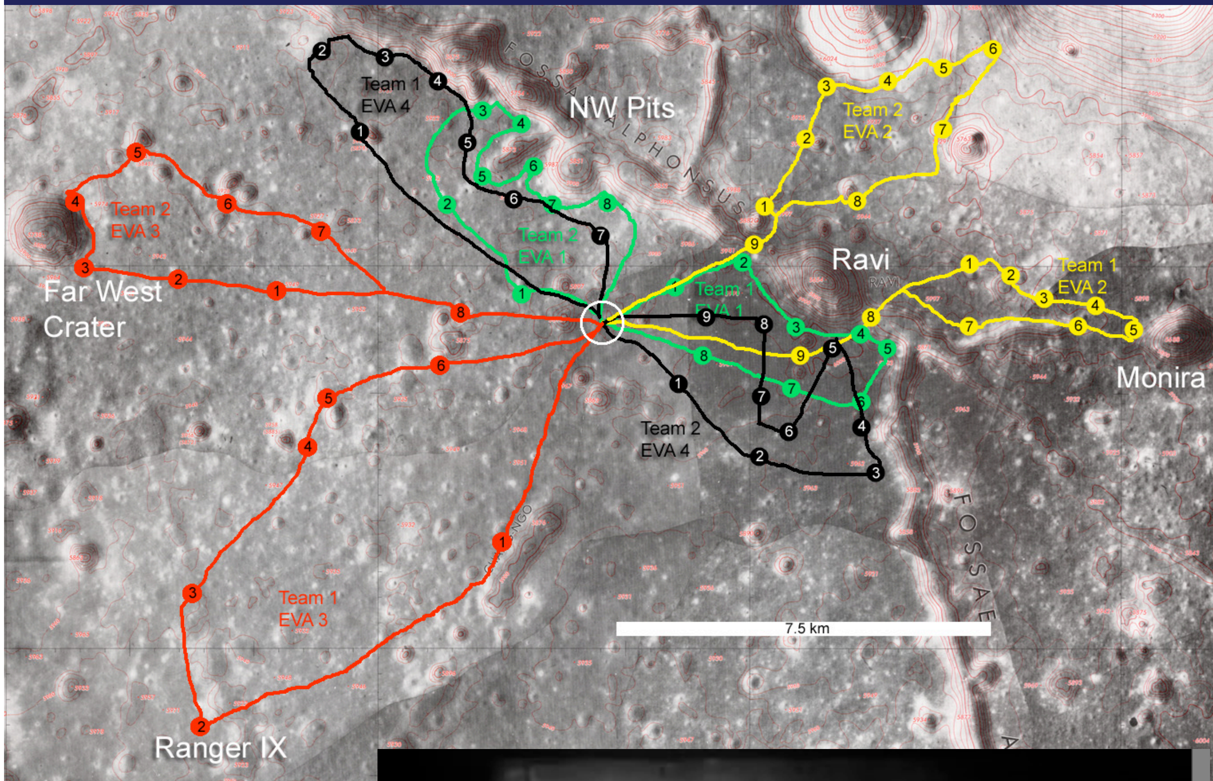


- 7 total EVAs to explore:
  - Higher-Fe melt
  - Lower-Fe melt
  - Higher-Fe mare
  - Lower-Fe mare
  - Small impact craters
  - Rille-like feature
  - Anorthositic kipukas
  - Anorthositic peak
  - Mafic-bearing anorthositic peak
- One EVA exceeds 10 km radius (32 km)
- All other EVAs < 20 km

ALPHONSUS


North
South
West
East
ALPHONSUS
RANGER IX IMPACT
Alphonsus K
Alphonsus B
Alphonsus D

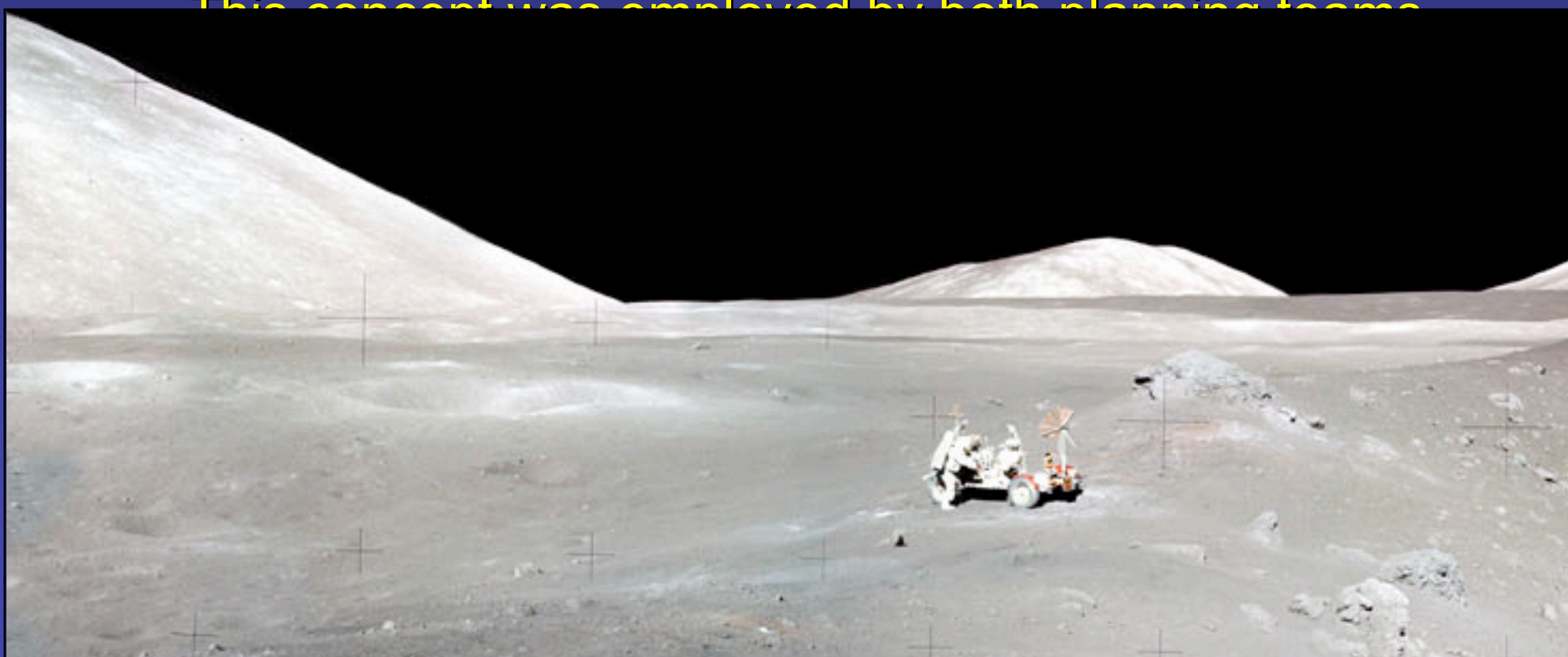
ALPHONSUS



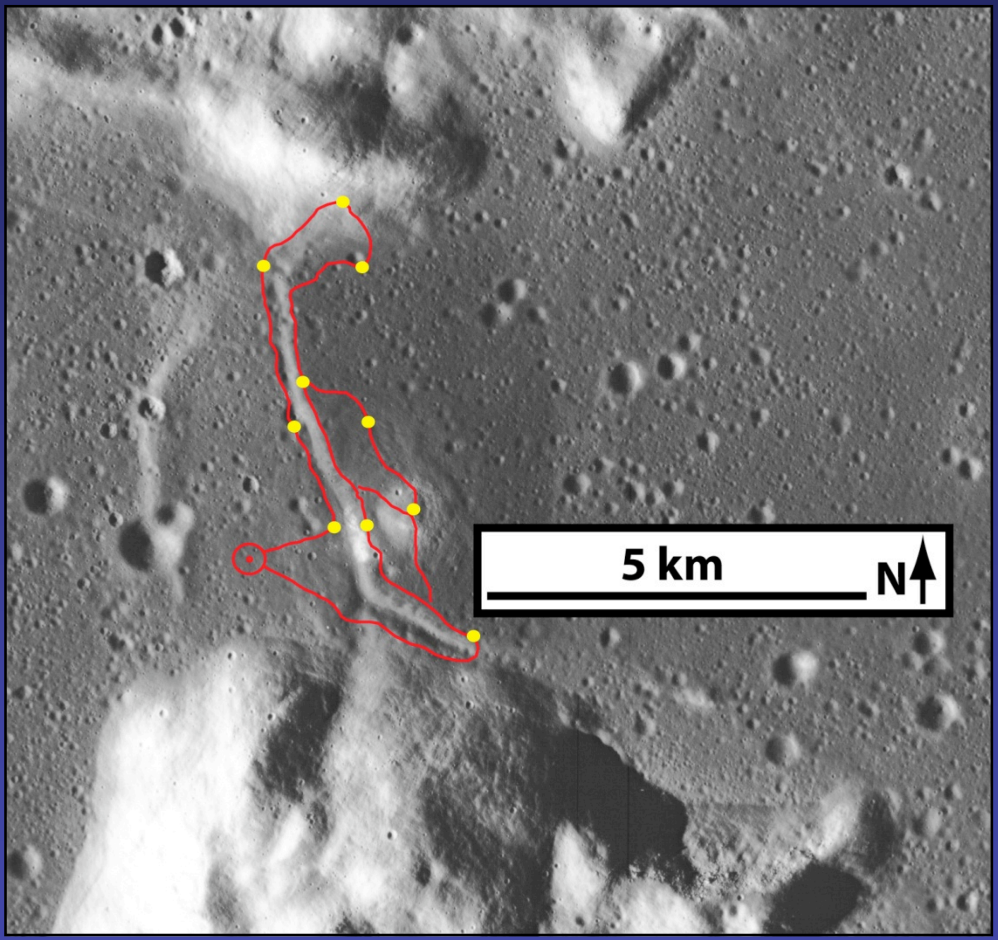
- 8 total EVAs to explore:
  - Dark halo craters (volatiles)
  - Pits
  - Melt sheet
  - Small impact craters
  - Ranger IX impact site
  - Regolith
  - Fossae
  - Highland crust
- Revisit dark halo craters and pits with different team
- All EVAs < 22 km

TESTABLE HYPOTHESES

- Basic EVA plans based on primary scientific objectives *and* dependent on testable hypotheses assessed in real time in the field
- Requires flexibility
  - EVA plans adjusted based on results of earlier field work
  - This concept was employed by both planning teams

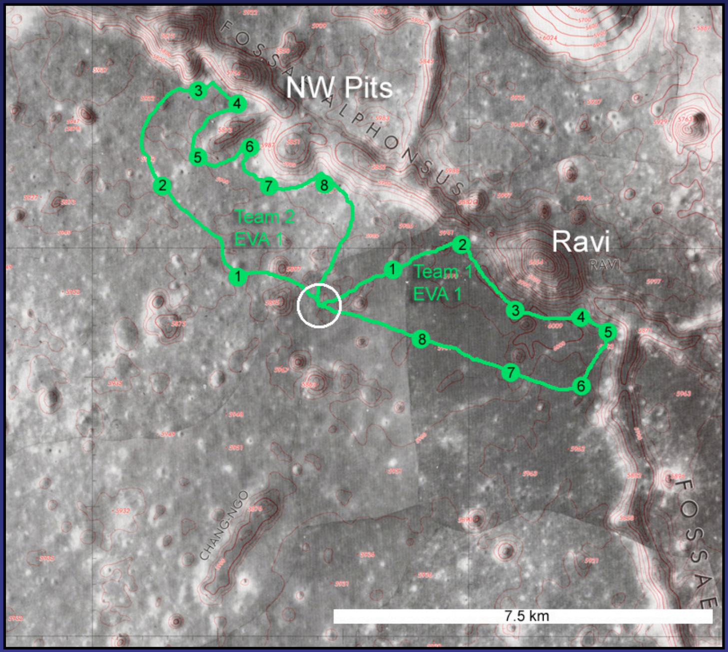


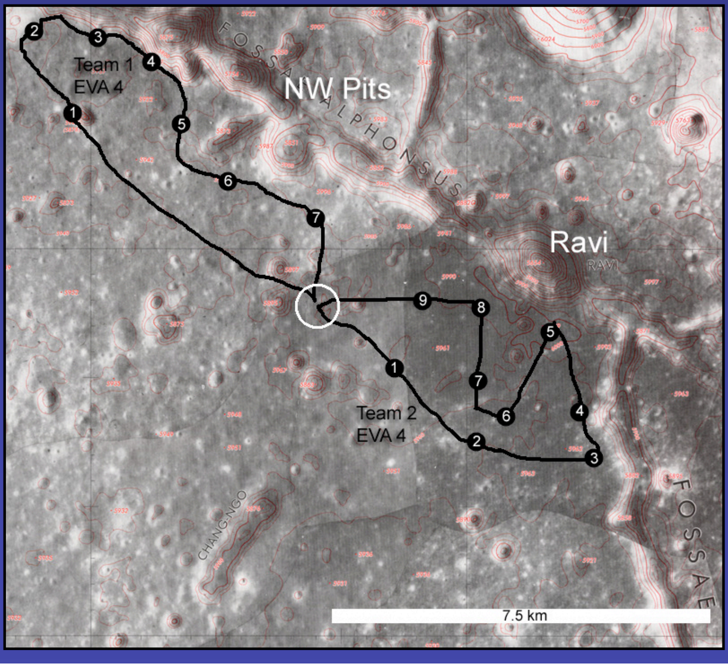
TESTABLE HYPOTHESES: TSIOLKOVSKIY



- Primary Objective: Determine origin of rille
  - Traverse entire rille length
  - Examine bedrock and stratigraphic contacts
- Secondary:
  - Assess nature of small highland kipuka
  - Characterize low crater density area and mare stratigraphy
- Secondary objectives dependent on initial assessment of rille from western scarp

TESTABLE HYPOTHESES: ALPHONSUS





- Primary Objective 1: Assess nature of volcanism related to pyroclastics and pits
  - Examine and sample dark mantle deposits
  - Examine and sample interior walls of pits
  - Examine and sample fossae
- Primary Objective 2: Assess lunar composition and evolution models
  - Sample mantle material in form of pyroclastics and possibly effusive volcanics
  - Sample highland crustal materials
- Second visit by second team allows follow up and new eyes

SAMPLING STRATEGY

- Sampling documentation strategy:
  - Collect UV-VIS-NIR spectra and multispectral context image for each sample site.
- For each site, collect bulk/scoop, rake, drive tube.
- Drag line and rake for sampling over steep slopes.
- Other sampling as Apollo 17.
- Conduct LRV sampling at predetermined intervals (or selected areas of interest) to collect regolith.
- Reconnaissance and some sampling carried out by robotic assistant/precursor => saves EVA time and enhances overall scientific return.

RECOMMENDATIONS

- Robotic mission designed as precursor *and* follow up is fundamental to maximize success of human mission.
  - Hazard assessment & scientific analyses
- Flexible EVA plans
- Mass of returned samples estimated at ~300 kg for 7-day sortie mission (based on Apollo 17 sampling); requires update of engineering plan.
- Enable scientific investigations with field instruments:
  - Digital handlens
  - Spectral cameras
  - Handheld geochemical analysis tools
  - Ground penetrating radar
- Deploy network or instrument station sites.
  - e.g. Geophones, seismic sources, surface magnetometers
- Continued support for ongoing efforts to geo-reference uncontrolled data sets.